Field Identification of Five Species of Californian Beach Hoppers (Crustacea: Amphipoda)

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WHILE STUDYING the correlations between the distribution of five species of beach hoppers of the genus *Orchestoidea* and the physical and biotic factors of their sandy beach habitat, it became necessary to identify with certainty the animals collected from the many beaches sampled up and down the Californian coast. Since it was desirable tentatively to name the hoppers captured in the field, I made an effort to find characters which were easily observed on the beach and would allow such identification. As a result of my examination of many thousands of animals from over a hundred collecting localities, I evolved a recognition of the five species mainly on the basis of pigmentation patterns, elements of which are relatively consistent in spite of the many variations to be found in the total pigmentation.

The species under consideration are the two large hoppers, *Orchestoidea californiana* (Brandt) 1851, and *O. corniculata* Stout 1913; the two somewhat smaller species *O. columbiana* Bousfield 1958, and *O. pugettensis* (Dana) 1853; and the small species, *O. benedicti* Shoemaker 1930.

Laboratory identification of these has been made possible by E. L. Bousfield (1957, and particularly 1959), to whom I am indebted for his help with some of the key characters. In these papers Bousfield has described a new species from southern California, *O. minor,* similar to *O. columbiana,* but with a few subtle anatomical differences. These will require statistical analysis in order to show more clearly the affinities of the two species. This newly described form will not be considered here since I have been mainly concerned with the beaches of central and northern California.

The pigmentation patterns may be relied on for identification of both sexes for almost all sizes of animals, with the following cautions: (1) The largest individuals of *californiana* almost invariably have lost the dorsal pigmentation, but color and form of the second antennae, as described below, will usually make this no problem; (2) the largest individuals of *corniculata* may have lost the dorsal pigmentation, but again, color and form of the antennae will usually suffice; (3) the smallest individuals of all species (under 4 mm in body length) may be so lightly pigmented as to make identification difficult or to require magnification and lighting available only in the laboratory; (4) animals living on white or very light-colored sands usually are only faintly marked, in which case combinations of other characters may have to be used.

Some general beach characteristics and hopper habits may also be of use in identification but are not dependable alone. *O. californiana* is typically found on long exposed beaches composed of fine sand, with few if any rocks present, beaches that are wide from the foreshore to back shore with dunes into which the hoppers may retreat during high spring tides and for breeding, beaches which usually have a quite flat foreshore, which is correlated both with exposure to wave action and with fine sand particles. *O. corniculata,* on the other hand, is typically found on shorter, more protected beaches composed of coarser sand, possibly with rocks or boulders present, beaches which may be narrow from foreshore to back shore with cliffs or piles of boulders preventing retreat during high spring tides (breeding animals are commonly found mixed with the rest of the population), beaches which may have a fairly steep foreshore, which is correlated both with protection from wave action and with coarser sand particles. These two animals are not often found together, but occasionally on a *californiana*-dominated beach, as at Carmel, California,

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corniculata hoppers may occur at the ends of the beach where conditions are not optimal for *californiana.* I have never found *californiana* on *corniculata*-dominated beaches.

For *columbiana* and *pugettensis* I have not gathered enough data to make very meaningful statements here. They often occur together on coarse sand beaches, some of which are quite long, onto which relatively little seaweed is cast as food for the hoppers. *O. benedicti* is commonly found with *californiana,* and otherwise lives on beaches of the finest, silty sand.

It is not always easy to find mature individuals in the daylight on a beach and much sample digging is often required to locate a "bed" of hoppers. Small individuals are readily found but are not so readily captured. The distribution of hoppers on a beach is not of a random nature, but is dictated by the location of seaweed, the main food of these omnivores, on the shore, and by the tidal cycles, which they tend to follow up and down the beach. Since these animals feed mostly at night on the freshest drift present and many remain under this drift at dawn, the most productive searching is usually done under the seaweeds brought ashore by a high tide of the previous night. Large individuals, however, may move farther up the beach; and in *californiana,* at least, the mature males and some females in the breeding season (probably February to October) with eggs or young in their brood pouches will be found scattered in fairly high and dry zones that may not have been reached by the surf for some days.

The location of the burrows of these large animals requires careful observation in the early daylight hours. In digging the burrow, or cleaning out an old one, large *californiana* kick sand out onto the surface in two opposite elongated rays. If this sand is of a different color because of a higher moisture content or because it was obtained from different-colored material below, it may be quite noticeable. However, during the day, drying action of the wind and sun may reduce the color difference between the burrow sand and the surface sand, and the winds level the elongated heaps, making them increasingly difficult to see. The burrows may be open shafts up to 12 inches in depth, with a plug of sand in the mouth of the burrow.

O. corniculata make burrow mounds much more like those of a pocket gopher. The sand is

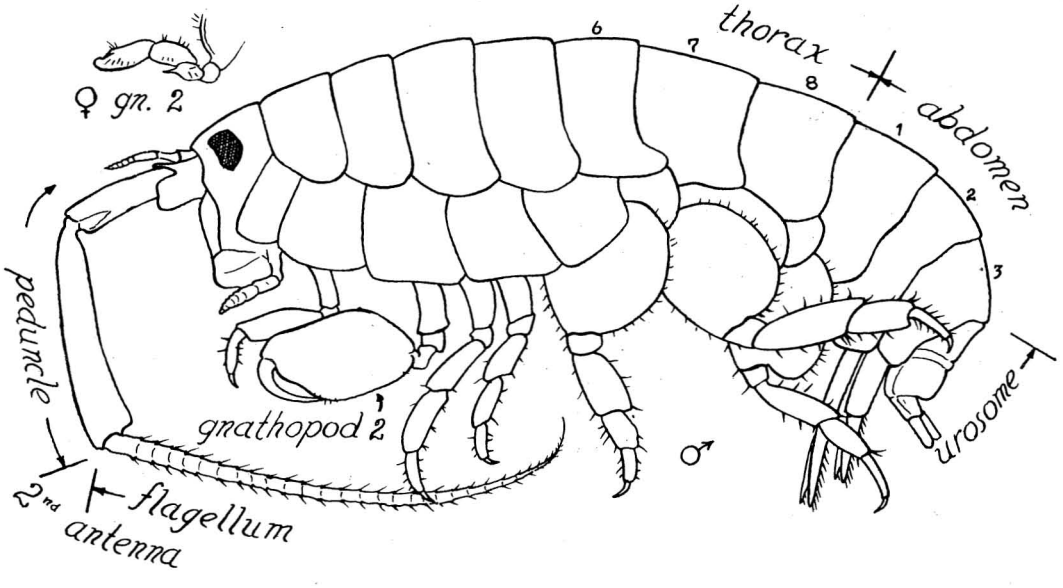

FIG. 1. Sketch of *O. californiana* to show features mentioned in the text.

pushed up less vigorously than by *californiana* and thus simply falls all around the burrow mouth in a rounded heap. Large individuals are usually found with smaller animals in mid- to high-tide zones rather than higher up on drier parts of the beach, as in *californiana.* The burrows are commonly open just around the hopper and are usually less than 6 inches deep, but I have found these hoppers more than 2 ft down.

The three smaller hopper species dig less than the large hoppers and thus do not make very obvious surface markings. They are more often found associated with washed-up debris.

I have found no sexual dimorphism with respect to pigmentation pattern, but the sex of these animals is easily distinguished by the structure of the 2nd gnathopods (the 2nd pair of large ventral appendages) except as noted below (see Fig. 1). In females the sixth segment is a fleshy paddle-shaped structure. In young genetic males the same form is present, but it becomes modelled through a series of molts into a larger subchelate "hand" with a curved dactyl closing against an emminence of the "palm." As far as I know, males can be distinguished from females only when the change in the gnathopods begins to be apparent. In *californiana* and *corniculata* this occurs when the animals reach about 9.0 and 13.0 mm in body length, respectively (measured from the anterior of the head through the chord of the straightened but still somewhat curved body to the back edge of the 3rd abdominal segment). Sexually active females possess oöstegites under the thoracic region. These are thin plates with a fringe of hairs, which overlap to form a marsupium in which eggs and young are carried. However, some large females lack these hairs, their presence apparently being dependent on the breeding cycle rather than on size. The 2nd antennae of females of all species are shorter and less robust than those of males, and are less colorful.

In midday, as the waves of a rising tide moisten a beach, it is common to see small animals moving around in the just-wet area, feeding on fresh bits of seaweed, washed up sand crabs, or seemingly just wandering. Probably all species do this, but in my experience this movement has occurred mostly with *columbiana,* less frequently with *californiana.* Under such conditions, an observer lying face down on the sand can use pigmentation patterns to distinguish the animals without even touching them.

FIG. 2. Left 2nd antenna of *O. corniculata* male. Compare this with appendage in Figure 1.

The most obvious character that distinguishes large male *californiana* from male *corniculata* is the form and color of the second antennae. In *californiana* the flagellum of the antenna is relatively thin, longer than the combined length of the segments of the peduncle, and gradually tapers to the tip, which reaches back beyond the middle of the body when folded from the peduncle base. The color of the peduncle is usually rosy-red. The peduncle segments are longer but not as massive as those of *corniculata.* In *corniculata* the flagellum of the antenna is thicker than in *californiana,* is shorter than the combined length of the peduncle segments, and tapers rapidly to the tip, which does not reach the middle of the body when folded (see Fig. 2). The color is usually salmon-pink, but sometimes, on a darker substrate, may be tinged with blue or brown. Newly molted individuals of both species may be white.

The antennae of *columbiana* are *californiana*-like, but in large animals are bluish-white rather than red. The antennae of *pugettensis* are *cor-*

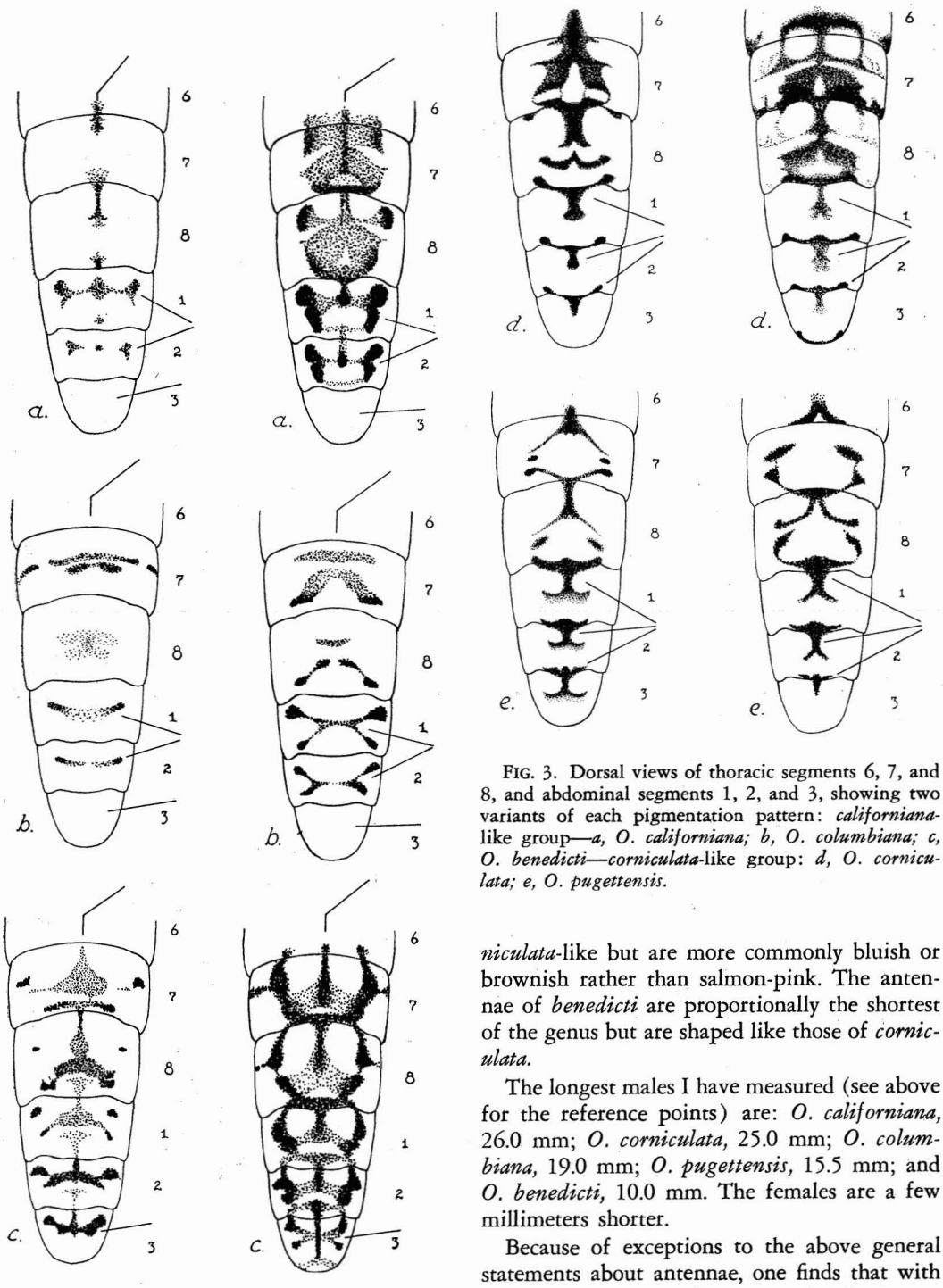

FIG. 3. Dorsal views of thoracic segments 6, 7, and 8, and abdominal segments 1, 2, and 3, showing two variants of each pigmentation pattern: *californiana*-like group—*a, O. californiana; b, O. columbiana; c, O. benedicti*—*corniculata*-like group: *d, O. corniculata; e, O. pugettensis.*

niculata-like but are more commonly bluish or brownish rather than salmon-pink. The antennae of *benedicti* are proportionally the shortest of the genus but are shaped like those of *corniculata.*

The longest males I have measured (see above for the reference points) are: *O. californiana,* 26.0 mm; *O. corniculata,* 25.0 mm; *O. columbiana,* 19.0 mm; *O. pugettensis,* 15.5 mm; and *O. benedicti,* 10.0 mm. The females are a few millimeters shorter.

Because of exceptions to the above general statements about antennae, one finds that with subadult individuals, females, and indeed even mature males from some beaches, other obvious

traits are needed for field identification. Generally, the overall pigmentation tone of these hoppers tends to match the color of the sandy substrate; but even on light sands where pigment is reduced, there are a few key spots that usually show up. I will be concerned mainly with the dorsum of the first three abdominal segments, which appear in a top view as the last three body segments ahead of the urosome, and the 7th and 8th thoracic segments.

A study of the sketches in Figure 3 will show that there are two main groups of pigmentation patterns. The broad "butterfly" spots of the 1st and 2nd abdominal segments of the "*californiana*-like" group are found with modifications in *O. californiana, O. columbiana,* and *O. benedicti.* The T-shaped spots of the 1st, 2nd, and 3rd abdominal segments of the "*corniculata*-like" group are seen in *O. corniculata* and *O. pugettensis.*

The californiana-*like group.* In *californiana* and *benedicti* there is a sagittal line showing in most variants of this pattern. Note the absence of pigment from the 3rd abdominal segment on *californiana,* but the presence of pigment in *benedicti.* In *columbiana* the midline marking is missing and the "butterfly" design is more nearly a flattened X, again with no pigment in abdominal segment 3. The characteristic markings of abdominal segments 1 and 2 are sufficient to separate *californiana* from *columbiana. Benedicti,* besides being small, is more heavily pigmented with discontinuous spots, which thus give the impression of a checkerboard design along the whole body.

The corniculata-*like group.* The two species in this grouping, *corniculata* and *pugettensis,* are the most difficult to separate, although they are easily distinguished from all the others. The most obvious dorsal pattern differences seem to be in the last two thoracic segments in which *pugettensis* has more delicate markings, but I have detected no easily recognizable differences here. A more consistent and reliable set of marks may be found at the lower margins of the lateral body wall in the last *three* thoracic segments of *pugettensis* (see Fig. 4). The third of these is missing in *corniculata,* which thus shows only *two* spots which are usually more diffuse and less intensely pigmented than in *pugettensis.*

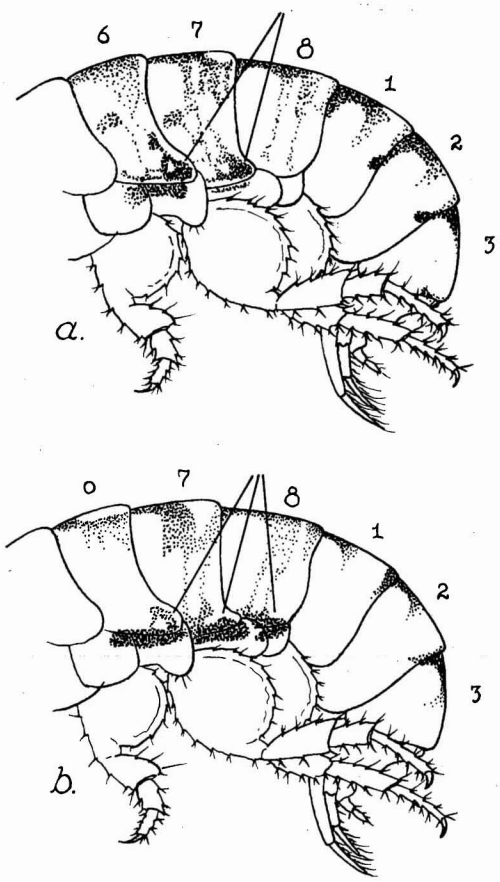

FIG. 4. Side views to show key characters of thoracic segments 6, 7, and 8. *a, O. corniculata; b, O. pugettensis.*

(These spots do not serve to set off these two species from the other three, however, for these others may have such markings as well.) These two hoppers are found on the same beach occasionally, and in such cases it may be necessary to rely on the key characters presented by Bousfield in the papers cited. However, these pigmentation patterns, antennae colors, and other more subtle clues allow one acquainted with the animals to make fairly reliable preliminary determinations.

Whatever "hedging" the reader may detect in this presentation is due to the wide range of variability to be found in these animals and to the fact that exceptions keep cropping up as

study continues. However, it is hoped that this discussion will make it easier to identify these animals in the field. I am grateful for financial support for this study which came in part from the American Academy of Arts and Sciences, and in part from the Mills College Faculty Research Fund. My thanks are here expressed to Dr. Joel Hedgpeth for helpful suggestions.

FIELD KEY TO SPECIES OF *Orchestoidea*

1. Mature animals 2
1. Immature animals and others not distinguished by first part of key 5

2. Second antennae when folded reaching back to or beyond middle of body; flagellum longer than peduncle 3
2. Second antennae when folded not reaching back to middle of body; flagellum shorter than peduncle 4

3. Color of 2nd antennae rosy-red ..... *californiana*
3. Color of 2nd antennae bluish-white ..... *columbiana*

4. Color of 2nd antennae usually salmon-pink ..... *corniculata*
4. Color of 2nd antennae not so 5

5. Dorsal pigmentation pattern containing "butterfly" designs 6
5. Dorsal pigmentation pattern containing T-shaped designs (Lower limb of T may be faint or missing) 8

6. Mid-dorsal line absent, "butterfly" spots flattened X's ..... *columbiana*
6. Mid-dorsal line present 7

7. No markings on 3rd abdominal segment; sides of body relatively free of pigmentation marks ..... *californiana*
7. Markings on 3rd abdominal segment; sides of body blotched with checkerboard pattern ..... *benedicti*

8. Two diffuse spots on sides of body ..... *corniculata*
8. Three discrete spots on sides of body ..... *pugettensis*

REFERENCES

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